# THE INSTITUTE OF PHYSICS

# BULLETIN

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# THE INSTITUTE OF PHYSICS

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THE INSTITUTE OF PHYSICS

Vol. 10 No. 12 **BULLETIN** DECEMBER 1959

*Published by The Institute of Physics for circulation to its members*

# What is a Physicist?*

By Professor H. LIPSON, M.A., D.Sc., F.Inst.P., F.R.S.

(*Manchester College of Science and Technology*)

We are all interested in physics. We are therefore all concerned with knowing exactly what we mean by the name. Nevertheless, I doubt whether a satisfactory definition of the subject exists, and the dictionaries usually play for safety by keeping to generalities. For a school of physics, however, this will not do; we must have some sort of general philosophy and try to fit our teaching to it.

For this reason the question "What is a physicist?" has been in the back of my mind for some years. The kind invitation of the Education Group to unload these ideas on to you is therefore welcome, particularly in helping me to crystallize my thoughts and put them into some orderly and logical sequence.

I may say, first of all, that a physicist is not simply one who has been trained in physics; he must have much deeper qualities than that. In fact, I believe that physicists are born, not made, and that by far the most important task of educationalists is to recognize the born physicist and see that he has the right environment —not necessarily a scientific one—as soon as possible. This task would be practicable only if each child had a separate tutor, himself sufficiently educated to recognize all the born physicists, musicians, linguists and so forth; in other words, it is impossible.

Let us then consider what *is* practicable in the present educational system of this country, in which, at the age of about fifteen, each child who shows signs of ability has to decide upon which art he wishes to lavish that ability. The school will advise, of course, and usually is fairly safe in the broad distinction between arts and science. But then the choice has to be made between the various sciences, and here the problems are more difficult. On what basis does the choice rest? How reliable is this basis?

To begin with, there are examination results. We all know how chancy those can be, and I am quite sure that any student who *has* to rely on them will not make a good physicist. The Secretary of the Joint Matriculation Board recently told how, one year, the State Scholarship awards were made before the marks were issued; several successful students telephoned the Board to ask for their results in order to decide what subject to take at the University!

They could not have been physicists; a physicist will know that he is interested in physics without having to be told by his examiners. I myself knew that I wanted to be a physicist at school—in spite of the improbability then of obtaining a job in the subject—even though in examinations I did better at mathematics and chemistry. (In my H.S.C. practical examination I forgot how to measure the density of a crystal of copper sulphate!)

If not examinations, then what? I suggest three criteria for distinguishing the embryo physicist. First, he must have curiosity. He must want to know the why and wherefore of his surroundings; in fact, this urge may well limit his performance in examinations since it may distract his attention to details outside the syllabus. Secondly, he must be capable of interesting himself in simple phenomena—the "simple" things like soap bubbles, and diffraction phenomena round street lamps during fogs. He will be capable of wonder at the action of a gramophone record. You will find him in his idle moments doing elementary physics of quite a useless nature—bringing objects into line, looking at diffraction patterns through his eyelashes, and so on. One wonders how many physicists in the middle ages were burnt as magicians for their odd actions! And thirdly he must be self-reliant. In the laboratory he will *make* apparatus work; he will not wait until the correct piece of equipment is obtained but will fashion something that will do from anything that is available.

I must admit that not many students come up to these standards. In the universities we have to be content with a large proportion of students who, in effect, have had physics chosen for them, and who will probably make quite useful scientists. But for the few who have the right qualities we must be sure that we provide the right background.

* Based on a lecture to the Education Group given at the Institute's House on February 11, 1959.

Let me say immediately that I am not making a plea for the dilettante; the days of men like Faraday who could make fundamental discoveries with very little training are almost certainly over. It is necessary that a student should undergo exposure to a systematic course of physics; otherwise he may be left with certain important gaps in his equipment. But, in addition, he must perform, for himself, as many experiments as possible with simple and easily recognizable apparatus. In particular, he should perform experiments that introduce relationships between different branches of physics; in his future work it is unlikely that he will meet problems that are isolated in their physical content.

As an example, I may quote an experiment on a sonometer with an electric current passing through it. The good physicist will at once see the line of approach—the energy dissipated in the wire, its rise of temperature depending on its specific heat and the heat loss from the surface, the expansion of the wire, the consequent decrease in tension depending upon its Young's modulus: nothing very complicated perhaps, but illustrating the relationships between practically the whole of elementary physics. I wish that I could also bring optics in!

I may be accused of placing too much emphasis on experimental physics and too little on theoretical. I do not claim to be a particularly good theoretician myself, and perhaps I am biased. Certainly physicists should have a good mathematical background, but I do not believe that mathematics can *make* a physicist; as a minimum, he should know enough mathematics to appreciate the derivation of physical results, and if he knows more it will certainly be an advantage. But he should not believe—as I am sure that some people do believe—that the first job of a physicist is to turn his physics into mathematical form and then deal with it by the mathematical processes he has learnt. Such a person—and I know that I take my life in my hands when I say it—is an applied mathematician rather than a physicist.

We may take my own research subject as an example. I am a physicist interested in the diffraction of X-rays; I do not like being called an X-ray crystallographer. The subject has been revolutionized since the end of the war by the introduction of computers, and methods are available that would not have been thought of ten years ago. For example, one of my staff has produced a program—called Woolfson's Folly—that gives probable sets of signs for the Fourier coefficients to enable a crystal structure to be derived. From the point of view of producing results it is good; from the point of view of research training it is disappointing, since research students tend to rush their data to it as soon as possible in the hope of obtaining results quickly. I am much keener on our optical-diffraction methods. They are not as direct, but they do require the student to think, and no one can claim to be a physicist without that.

Having then exposed students to this type of education—in the original sense of the word, that is, of leading out that which is already there—how do we measure our success? Examinations. This is the stiffest problem of all—and not only to the student. The other problems can be considered at leisure, and adjustments and modifications introduced as we proceed. But examinations are, relatively speaking, over in a flash. Here, therefore, we must move particularly carefully.

The cardinal trouble is, I think, that theoretical physics is so easy to examine and experimental physics so hard. We in Manchester have given up practical examinations; we keep careful observation of practical work during the session and drop the pretence that in one day we can gain a better idea of a student's capabilities than we can over the years he is with us.

But written papers are necessary, and of course these must contain much basic theory. But the true physicist is not recognized merely by his ability to reproduce bookwork, or even to solve problems based directly on bookwork; he must be examined on his ability to recognize which branches of physics enter into set problems, and he should be given opportunities to show his interests in physics in general. I agree that these types of questions are more difficult to mark than questions on theoretical physics. But have physicists ever been deterred from doing something merely because it is difficult?

I like the idea of the fallacy questions advocated by Dr. A. D. Maude,[1] except that they would enable us to pick out only the first-class people; the rest would be consigned to the limbo of the lost!

Now we hope that we have produced our physicists. There will of course be relatively few of them, but they will be distinguished by their enthusiasm (and not only for physics, I am sure). They may not have enough knowledge to tackle *any* problem they may meet, but they will be able to appreciate the principles involved and know where to turn to get the help they need. They will produce the new ideas that keep physics going, and in that way they will keep on learning all their lives.

I am conscious that in putting forward my ideas I am probably swimming against the stream. Perhaps I am unjust to theoretical physicists, but in my defence I should like to quote our President, writing on his father:[2]

" In all his theories J.J. liked to visualize, and for him the mathematics were always merely the language which described the physical and special concepts in his mind. He had no idea of mathematics dictating the theory. In this he was definitely of the era of Kelvin rather than that of Bohr, still less that of Dirac. This view is out of fashion for the moment, though perhaps not so completely as is sometimes thought. Fashions in physics are hardly more stable than in ladies' waistlines, and even his tubes of force are coming back, as a most useful description of what happens in some of the new devices for raising gases to the enormous temperature needed to produce thermonuclear energy."

I think that it is the purpose of talks such as these to be provocative, and I hope that at least I have made out a case that can be pulled to pieces.

REFERENCES

1. A. D. Maude. " The Fallacy in Physics and Mathematics." *Bulletin of The Institute of Physics*, Vol. 9, No. 12, Dec., 1958, p. 318.
2. George and Joan Thomson. "J. J. Thomson as we remember him." *Notes and Records of The Royal Society of London*, Vol. 12, No. 2, Dec., 1957, p. 203.

*Vol. 10, December, 1959*

# An Applied Physics Sandwich Course for the Diploma in Technology

By F. Y. POYNTON, M.Sc., F.Inst.P.

(*Northampton College of Advanced Technology, London*)

A FEW months ago the first group of students taking a Diploma in Technology Applied Physics Course at the Birmingham College of Technology passed their final examinations and they will be awarded the their final examinations and were awarded the Diploma later in the year when they had completed their industrial training. Two other groups from Brunel and Northampton Colleges have now taken their finals and so a small number of young physicists trained in this new way and holding this new award are now working in industry. In view of this it seemed appropriate that the *Bulletin* should publish some account of the scheme and the progress so far made in its development. As a contribution to this I welcome the opportunity of giving a report on what is being done at the Northampton College of Advanced Technology.

Since the Diploma in Technology is of so recent origin it may be useful to state briefly the main features of the scheme. The Diploma in Technology is a nationally recognized award of a standard equivalent to that of an honours degree, created and administered by the National Council for Technological Awards (N.C.T.A.) an independent self-governing body set up for that purpose by the Minister of Education in 1955. The courses for the award are designed by the colleges and both college and course must be approved by the Council. The examinations are in the hands of the college staff acting together with one or more external examiners. The general purpose of the scheme is to help bring about a state of affairs in which the major colleges of technology are free to use their special experience and resources in the development of new types of course through which they can make a distinctive and more effective contribution to the training of the greatly increased number of applied scientists which the country so urgently needs.

The course at the Northampton College was started in January, 1956. At that time the award was the College Diploma in Applied Physics which the Board of the Institute had agreed to recognize as giving exemption from their Graduateship examinations. The scheme, practically unchanged in form, was submitted to the National Council in 1957 and was approved with retrospective recognition from the date of the commencement of the course.

## GENERAL PLAN OF THE COURSE

It was decided at the outset that the course should be of the sandwich type, the student spending in each year approximately equal continuous periods in industry and in college. The guiding idea was to develop a scheme in which the academic work and the industrial training would form equally important parts and be co-ordinated as closely as possible, and it seemed that this objective could best be achieved by the plan we adopted. It calls for a very close and continuous co-operation between college and firm. It was decided after much consideration that the overall duration of the course should be four years. In this we were influenced considerably by the fact that at the time most of the industrialists who were enthusiastic about the scheme preferred this period. There are obvious arguments in favour of an additional year, particularly from the point of view of the attainable academic content of the course, though some of these considerations could equally be used in favour of a still further extension. A line must be drawn somewhere. Our experience so far seems to support the view that the four-year period is a reasonable compromise, but it may well be that this should be reconsidered in a few years time. A possibility worth examining would be the extension of the course by the addition of a fifth college period, making the overall duration four and a half years.

## ENTRANCE CONDITIONS

For admission to the course, a student must satisfy the following minimum conditions :

Either (*a*) have passed in five subjects in the G.C.E examinations including English language at O level, physics at A level and one of pure mathematics, applied mathematics or pure and applied mathematics at A level.

or : (*b*) have obtained an Ordinary National Certificate in either applied physics or electrical engineering with a minimum of 60 per cent in all assessed examinations.

All students are interviewed before acceptance.

## ENROLMENTS

For the first three years we had one group per year, the college period extending over 26 weeks. In September, 1958, a new scheme was introduced with two intakes per session, one group starting in September and the other in February. With this arrangement each group will be in college for 24 weeks in each of the first three years and for an extended period in the final year. The college has decided as a general policy to adopt this " end-on " plan for nearly all its Diploma courses. There is clear evidence that it is welcomed by many firms and we feel that if the whole enterprise is to succeed, colleges should co-operate in this way wherever it is possible. Moreover the longer college period in the final year has much to commend it, particularly with regard to the project work in that year. The enrolments for the courses have been encouraging, the numbers being as follows : 1956 (Jan.) 12 ; 1957 (Jan.) 33 ; 1958 (Jan.) 34 ; 1958 (Sept.) 17 ; 1959 (Feb.) 24.

At the present moment over 100 students are in attendance at the college.

The students come from many different places including government establishments, public authorities and more than twenty firms, mostly large ones. In practically all cases they are fully supported by the organization concerned. A few have County Major Awards covering their college periods and have been promised employment during their industrial period. In one or two of these cases the student has been taken on fully by the firm after the first year.

By far the greater number—about 75 per cent—of the students enter with G.C.E. qualifications and of these the large majority—70 per cent—have at least three A level passes. The O.N.C. entrants have done quite as well as those with G.C.E. and include among their number some of the best on the course. Three have been admitted directly to the second year in virtue, primarily, of good performances at the Higher National Certificate. Of the total number entering the course up-to-date approximately 10 per cent have failed at some stage and withdrawn, mostly at the end of the first year.

Speaking generally we are very pleased with both the intellectual calibre and the personal qualities of the students. Great trouble has been taken by the firms in their selection and this is reflected in the high level of enthusiasm shown by the students. While most of them are fairly recent school-leavers, a number are of a somewhat older age group, and this fact, together with their more varied back-grounds and the experience which all gain in their industrial periods, is no doubt responsible for the very noticeable "character" and zest each group exhibits. This has been commented on by many of the staff who have contrasted it favourably with the comparatively less interesting and undifferentiated character of classes in which all the students have come direct from school.

### THE CURRICULUM OF THE COURSE

| | *Average hours per week* |
|---|---|
| ***First Year*** | |
| Physics (including Electronics) ... | 5 |
| Practical Physics (Pure and Applied) | 5 |
| Mathematics ... ... ... | 5 |
| Chemistry ... ... ... ... | 3 |
| Technical Drawing ... ... | 2 |
| Workshop Technology ... ... | 2 |
| Liberal Studies ... ... ... | 3 |
| | 25 |
| ***Second Year*** | |
| Physics ... ... ... ... | 5 |
| Applied Physics ... ... ... | 2 |
| Practical Physics (Pure and Applied) | 6 |
| Mathematics ... ... ... | 5 |
| Chemistry ... ... ... ... | 1 |
| Metallurgy ... ... ... ... | 1 |
| Electrical Technology ... ... | 2 |
| Liberal Studies ... ... ... | 3 |
| | 25 |
| ***Third Year*** | |
| Physics ... ... ... ... | 5 |
| Applied Physics ... ... ... | 4 |
| Practical Physics (Pure and Applied) | 8 |
| Mathematics ... ... ... | 4 |
| Industrial Administration ... ... | 1 |
| Liberal Studies ... ... ... | 2 |
| | 24 |
| ***Fourth Year*** | |
| Physics ... ... ... ... | 4 |
| Applied Physics ... ... ... | 5 |
| Practical Physics (Pure and Applied) | 4 |
| Project ... ... ... ... | 6 |
| Mathematics ... ... ... | 1 |
| Industrial Administration ... ... | 1 |
| Liberal Studies ... ... ... | 2 |
| | 23 |

The hours given for physics and mathematics include tutorials and those for chemistry, metallurgy and electrotechnology include some laboratory time.

### COMMENTS ON THE CURRICULUM

In planning the curriculum the primary aim has been to provide a thorough training in the fundamentals of theoretical and experimental physics, suited by its content and mode of treatment to the needs of those taking up a career as applied physicists, i.e. physicists who would be occupied in industry with the application of the basic principles and methods of physics to the design and development of new devices, processes and materials and other problems of industrial physics. We have discussed the design of the course with many industrial physicists and the scheme adopted owes much to their advice. It would be inappropriate and impracticable in the space of this article to consider the details of individual syllabuses although it is here that much of the difficulty as well as interest arises. The following comments may however help to make clearer the ideas which have guided us.

*Physics.* Without going into details little useful comment is either necessary or possible here. The greater part of the syllabus is devoted to classical physics, that is mechanics, heat and thermodynamics, vibrations and wave-motion, optics, electricity and magnetism; and in dealing with this we have tried to emphasize the unity of the subject by concentrating on the main principles and concepts and the technique of their application. With regard to modern atomic, solid-state and nuclear physics, we have limited the treatment to a broad survey of the experimental basis with an introduction to quantum theory and statistical mechanics.

*Applied Physics.* The introduction of an appreciable amount of material of an applied character into the curriculum constitutes one of its distinguishing features and calls for some explanation. There are two reasons for the inclusion of such material: (1) as a means of illustrating and illuminating basic principles; (2) in virtue of its own intrinsic interest and usefulness. Of

these, we regard the first as the more important. All students want and need to be shown the principles in action and this is particularly true of the type of student with which we are concerned, whose interest is primarily in the practical applications. For such students the exploration to a limited extent of some selected fields of applied physics is of great benefit. Far from being an added burden taking time from the study of fundamentals, it provides the stimulus of lively interest and enables the student to grasp more clearly and firmly the basic ideas involved and to appreciate the technique of applying them. On the other hand the addition of any material to the curriculum based on the second of the above reasons alone calls for very careful consideration. There are so many things about which it would be useful for the student to know something, and many persuasive suggestions are forthcoming from enthusiasts for the inclusion of this or that topic. It is clear, however, that in this way it would be only too easy to produce a course in which far too much time was being devoted to the mere accumulation of factual information. Everyone would agree this is highly undesirable. The object is to produce active minds, not loaded memories and we have taken this as our guiding principle in deciding what applied topics should be included and how far they should be developed.

*Electronics*. We have included this subject in each of the first three years of the course and it forms one of the Applied Physics options in the final year. The almost universal use of electronic instruments and techniques throughout industry makes it essential that every applied physicist should be well acquainted with the basic principles involved. Moreover, the study of electronics provides many excellent opportunities of illustrating fundamental physical concepts in a very stimulating way and we have tried to develop the course in such a way as to make the fullest use of these opportunities. We decided to introduce some elementary electronics in the first year because it seemed to us desirable that students should begin to acquire as early as possible some familiarity with electronic equipment.

*Vacuum technology, Spectroscopy*. These two subjects together with electronics, constitute the Applied Physics of the second year. The production and measurement of high vacua are involved in so much of the experimental work of the physicist that some introduction to this topic is obviously desirable for its intrinsic value. Moreover, again if the emphasis is placed on the fundamental principles involved, it makes a considerable contribution to the study of the kinetic theory of gases. The short course in spectroscopy is closely correlated with the work on light and atomic physics. It is primarily concerned with spectroscopic equipment and an introduction to spectroscopic analysis. Lectures on photography as a scientific tool are included.

In the third year the Applied Physics includes in addition to electronics, three short courses on x-rays, acoustics, and automatic control. The x-ray course is concerned with an introduction to the elements of x-ray diffraction and its practical applications. It involves a little crystallography and in that way contributes to the general study of materials but its chief value lies in the broader appreciation it provides of the principles of physical optics. The work in acoustics and automatic control is closely linked with the electronics and a general course on vibrations and wave-motion (mechanical, acoustical, and electrical) which is given in the same year.

In the final college period some specialization is introduced and the student selects two subjects from a list of applied physics options. By the time he has reached this stage in the course he will have found in one way or another some field of special interest and it seems desirable he should have the opportunity of spending an appreciable amount of time in studying more thoroughly some topics which particularly attract him. The present final year students are taking either automatic control and advanced electronics or automatic control and nuclear instruments and measurements. Next year the options will include, in addition to these, x-rays, solid-state physics (electrical) and an introduction to nuclear power. About a third of the time in this final year is devoted to these options.

*Projects*. During this period also, each student carries out a project which will usually be related to the particular applied physics options which he has selected. Although the first set of projects have all originated in the college, in future years use may be made of projects arising from the student's industrial experience. It should be borne in mind that the time available for the project is equivalent to about one month's full-time work and many otherwise suitable investigations have to be rejected because they would take too long. It has been suggested that the major portion of the project might be carried out in the final industrial period. This procedure would have certain obvious advantages but it might be found very difficult in practice to assess the relative performance of students in different establishments.

Our present procedure is to give the students their particular project about two months before they return to the college for the fourth year. The first eight weeks of this college period contains conventional laboratory work only so that the students have about four months in which to carry out the necessary reading and to make preliminary plans. During the remainder of the college period the practical work, which is concentrated on two days per week, is devoted entirely to the project. The students are expected to construct their apparatus where this is desirable, and workshop facilities are available for this purpose. Each student is required to keep a laboratory notebook in which the day-to-day work is recorded and at the end of the project to prepare a short dissertation on the project.

### ANCILLARY SUBJECTS

*Mathematics*. With regard to the content and treatment of the mathematics syllabus we are making an effort to put into practice some of the guiding principles presented in the Institute's pamphlet on the subject and in particular to work out as close a correlation as possible between mathematics and the physics. The difficulties involved are certainly quite considerable and we are by no means satisfied. However, some progress has been made and I am convinced that the close co-operation of mathematics and physics staff

in this matter is of great benefit to the student. Apart from the usual content of pure and applied mathematics (in the narrower sense) we have included in the syllabus some statistics, numerical analysis and computing.

*Workshop Technology and Technical Drawing.* In many cases it has been possible to arrange for the student to take an organized course in one or both of these subjects as part of their industrial training. Where this has been done the subject has been omitted from the college curriculum and the time left free.

*Electro-technology.* The object of this course, taken in the second year, is to provide a practical knowledge of the most commonly occuring types of engineering equipment :—generators, motors, transformers, and supply systems. It is obviously very desirable that experimental physicists should be well acquainted with these matters and the study of them provides further illumination of the fundamental principles of electricity.

*Chemistry and Metallurgy.* The Chemistry included in the curriculum consists of a general course in the first year dealing with the elements of physical and inorganic chemistry and two short courses in the second year, one giving an introduction to the more important concepts and principles of organic chemistry and the other to physical metallurgy. This work in chemistry is introduced because of the basic contribution it makes to the study of materials. In view of the great part played in modern industrial physics by the development of new materials—alloys, plastics, rubbers, adhesives, ceramics, etc., we have throughout the course placed special emphasis on the study of materials.

*Foreign Language.* Up to the present we have not allotted any time in the curriculum to a study of a foreign language. We are, however, arranging for classes in both German and Russian to be available in the early evening for students who wish to take one or other of these languages.

*Liberal Studies.* The few hours per week of the curriculum described in this way are devoted to courses of lectures and discussions on a variety of subjects including history of science, social history, general philosophy, ethics (with special reference to the ethical responsibilities of scientists), economics, social psychology and communication. The procedure adopted is to cut down formal lecturing to a minimum and encourage the students to read as widely as time permits and to join fully in discussions. We are admittedly still experimenting in this exercise and have much to learn but I am sure the students appreciate the purpose behind it.

### EXTRA CURRICULAR ACTIVITIES

The college has a vigorous Students' Union Society with a variety of clubs and societies affiliated to it. The physics diploma students have recently added to these by forming a Physical Society which has made a very successful start, with a full programme of visits, film shows, students' papers, and addresses from visiting lecturers.

### INDUSTRIAL TRAINING

Undoubtedly the most distinctive feature of the sandwich method of training is the alternation of academic study and industrial experience. It cannot be too strongly emphasized that the periods in industry are an integral part of the course. The whole scheme is a co-operative enterprise shared equally by the college and the firms. The National Council rightly stresses this aspect and places upon the college the responsibility of working out, in collaboration with the industrial representatives, suitable programs of progressive practical training correlated, as far as is possible, with the work done in the college. It requires assurance that students have satisfactorily completed such training before the Diploma is awarded.

In the field of engineering considerable experience has been accumulated and is available to serve as guidance, but for physicists the problem is largely a new one. With the rapid increase in the number of physicists in industry the position is changing and the present development of sandwich courses offers an opportunity for looking into the matter. I would like to suggest that the Education Committee of the Institute might be asked to give some attention to the problem. In some ways it differs appreciably from that in engineering since the majority of physics apprentices are employed in research and development laboratories rather than on the production side and it appears that they will, in general, continue to be so employed after they are qualified. It seems proper therefore that the major part of their industrial training should be directed to acquiring an appreciation of the methods of attack on typical problems encountered in the application of physics in industry, and, undoubtedly, the most vital and effective way of achieving this is to be found in the experience of working with senior physicists on specific projects. If these tasks are suitably chosen they will incidentally ensure that the student gains some skill in a variety of experimental techniques. It would clearly also be very helpful, as mentioned earlier, if the firm were able to provide training in engineering workshop practice and technical drawing preferably in the first industrial period. At a later stage it would probably be desirable that the student should have the opportunity of obtaining some understanding of administrative problems and some experience in collaborating with development and production engineers.

Our procedure has been to appoint a senior member of the staff to act as a liaison officer with each firm or establishment and as a tutor to the students concerned during their college period. He pays several visits—always two, and usually three—to the firm during each industrial period. The primary purpose of these visits is to see the work the student is doing and talk to him and his supervisor about the progress he is making. We have found these personal contacts to be of great value. In some cases it has been possible on the last visit in any period to decide the general type of work in which the student will be engaged in the following period; in other cases this has been considered with the firm's Education Officer when he comes to see the student at the college.

In all our discussions we have not as yet made any attempt to work out any pre-determined scheme of correlation between the work the student is engaged on during the industrial period and his academic work. It is doubtful whether any such scheme is feasible

even under ideal conditions and as this is hardly ever the case, and the facilities vary so much from one establishment to another, the exercise is a rather theoretical one. We have concentrated on the practical *ad hoc* problem of securing the best possible use of the training period. It is not of course always possible to reach a fully satisfactory solution but in all cases we have found the industrial staff willing, and indeed anxious to find the best possible arrangement, even when this has involved them in considerable trouble. As an example of the kind of thing we have been able to do by way of correlation, it is perhaps worth mentioning that in not a few cases it has been possible for the firm to assign the student to work dealing with a subject in which he has shown some weakness.

In general it is clearly desirable that the student's work should be suited in difficulty to his knowledge and maturity. His tasks should call for some initiative and be such as can reasonably be completed in the time available. Incidentally in this context, I think it is worth commenting that the visits of the college staff to various establishments have been of very great value to the staff themselves. They are making a valuable contribution to forming the closer liaison between Education and Industry which is so much to be desired.

ACADEMIC WORK DURING INDUSTRIAL PERIOD

It is obvious that in a sandwich scheme of this type it is vitally important that habits of study should be maintained throughout the industrial period. In this period the student, released from the intense concentration needed during term time, can pursue further reading in a more leisurely manner. We have done our best to encourage this. Indeed it is one of the advantages of the industrial period, that it allows time for the assimilation of theoretical work of the preceding college session. We have thought it neither desirable nor proper to try and organize any continued classes or anything in the nature of a correspondence course. The only formal work we have asked for consists of two essays—one on a technical or scientific subject and the other on a liberal studies topic. Apart from this we have contented ourselves with providing some suggestions as to suitable reading. Experience shows that students have on the whole, made excellent use of this time, in many cases greatly helped by the stimulating environment in which they have been working.

Speaking generally of the Diploma in Technology Sandwich Scheme in the light of the experience gained in the last few years, I feel that we may be reasonably satisfied with the progress that has been made. My initial enthusiasm has been greatly increased by the support received from industrialists. Their co-operative attitude is most encouraging and I am confident that we are at the beginning of a significant development in the training and education of physicists It is a scheme which is complementary to, rather than competitive with other existing ones. No doubt modifications will be made and a good deal of work remains to be done before the full potentialities of the plan are realized. I am sure, however, that it is on the right lines and within a few years will be making a very useful contribution to the supply of physicists for industry.

# Forthcoming Institute Meetings

(The second half session program will be published in the January issue of the *Bulletin*)

| *Date* | *Place* | *Speaker* | *Title* | *Time* | *Branch or Group* |
|---|---|---|---|---|---|
| 1960 | | | | | |
| Jan. 11 | **London** The Institute's House | Professor J. G. Wilson, F.Inst.P. (*University of Leeds*) | **The problem of primary cosmic radiation** | 6.00 p.m. | London and Home Counties |
| Jan. 14 | **Liverpool** The University | Dr. E. Mendoza (*University of Manchester*) | **Electronic applications of superconductivity** | 7.00 p.m. | Liverpool and North Wales |
| Jan. 15 | **Bristol** The University | Mr. A. J. Garratt, M.B.E., A.Inst.P. (*International Scientific Research Exhibitions Ltd., London*) | **Science on television** | 7.00 p.m. | South Western |
| Jan. 15 | **Newport** College of Technology | Dr. J. W. Menter, F.Inst.P. (*Tube Investments Research Laboratories, Cambridge*) | **The microstructure of crystalline solids** | 6.00 p.m. | South Wales |
| Jan. 18 | **Manchester** The University | Dr. J. B. Birks, F.Inst.P. (*University of Manchester*) | **Recent developments in scintillation counting** | 7.00 p.m. | Manchester and District |
| Jan. 20 | **London** The Institute's House | Mr. H. J. Dunster (*Health and Safety Branch, United Kingdom Atomic Energy Authority*) | **Health physics** | 6.00 p.m. | Education |

# Notes and News

**Payment of subscriptions**

Members are reminded that a form to be sent with remittances for 1960 subscriptions and for Journals at special rates will be included in the January *Bulletin*. They are asked not to send subscriptions until this form is issued.

**Journals at members' rate**

The Institute's Journals for 1960 will continue to be sent to those members already subscribing, unless notice of cancellation is received by the Secretary before the end of this year.

**Joint British Committee for Vacuum Science and Technology**

Following the Institute's London conference on high vacua held in April last, various suggestions were made for arranging regular British meetings on vacuum science and technology, and for British participation in international conferences in this field.

As a result of informal discussions between societies and institutes in this country a "Joint British Committee for Vacuum Science and Technology" has now been formed. The Committee consists of representatives from each of the following bodies :—

The Institute of Biology
The Institution of Chemical Engineers
The Royal Institute of Chemistry
The Institution of Electrical Engineers
The Iron and Steel Institute
The Institution of Mechanical Engineers
The Institute of Metals
The Institute of Petroleum
The Physical Society
The Institute of Physics.

Its objects are :—

(*a*) To co-ordinate and help to initiate meetings in the whole field of vacuum science and technology arranged by constituent bodies and

(*b*) to act in the collective interest of the constituent bodies by maintaining liaison with the International Organization for Vacuum Science and Technology and with national vacuum societies, and otherwise.

The Institute of Physics has agreed to provide the secretariat for the joint committee ; communications should be addressed to the Secretary of the Joint British Committee at the Institute's House, S.W.1.

**Conference on solid state microwave amplifiers**

A joint Conference of the Radio Spectroscopy Group and the Institute's Electronics Group will be held in the University of Nottingham on April 6, 7 and 8, 1960. The title of the Conference is "Solid state microwave amplifiers" and topics to be discussed will include masers, parametric amplifiers and related resonance studies.

Accommodation will be available in a University Hall of Residence. Details are obtainable from the Secretary of the Institute.

**Textile Institute : Physics Group**

The Textile Institute has recently formed a Physics Group. One of its purposes will be to have small conferences, probably one a year, to discuss in detail certain aspects of physics applied to the Textile Industry.

At the first meeting in Buxton during October, five papers were presented and discussed ; to preserve informality and liveliness in discussion no records were taken. At future meetings members of The Institute of Physics who are not members of The Textile Institute will be welcome ; it is hoped that physicists whose work is in allied fields may find some stimulation in these meetings as well as contributing from their own experience. Tentative plans have been made to hold the next meeting in Harrogate on September 22 and 23, 1960, probably on a general theme of the physics of fabrics. More details will be available during March, 1960. In the meantime anyone interested is invited to write to the Chairman of the Group, Dr. H. O. Puls (*Fellow*), British Nylon Spinners Ltd., Pontypool, Mon.

**Physical Society Acoustics Group Symposium**

The Acoustics Group of The Physical Society will hold a symposium on the subject of "Vibration" in the Physics Department, Imperial College, Imperial Institute Road, London, S.W.7, at 2.30 p.m. on January 20, 1960.

Papers will be read on the analysis of noise-excited vibrations in aircraft, on vibration-isolation of large tensile machines, on ground vibrations and on the influence of vibration, including that from small power tools, on the human body. Speakers will include Professor E. J. Richards and Dr. B. L. Clarkson of Southampton University, Dr. P. Grootenhuis and Dr. N. Ambraseys of Imperial College, Dr. J. N. Agate, formerly of the London Hospital and Flt.-Lt. Guignard of the R.A.F. Institute of Aviation Medicine. Tea will be available at 5 p.m. and the meeting will close at about 6.45 p.m.

**Discussion Meetings on Reliability and Maintenance of Digital Computer Systems**

The British Conference on Automation and Computation is sponsoring meetings on January 20 and 21 on Managerial and Engineering Aspects of the Reliability and Maintenance of Digital Computer Systems. The meetings are to be held at The Institution of Electrical Engineers, Savoy Place, London, W.C.2, and those wishing to attend should obtain registration forms from the Secretary of that Institution.

**Simon Memorial Prize**

The establishment of a Simon Memorial Prize by the Low Temperature Group of The Physical Society was announced in the July *Bulletin*. The first award of the prize has been made to Dr. Heinz London of the Atomic Energy Research Establishment, Harwell.

**Contemporary Physics**

A new bi-monthly journal *Contemporary Physics* is being published by Taylor & Francis Ltd. and is edited by Mr. G. R. Noakes (*Fellow*). A review of the first issue appears on page 313.

**Engineering education in the London region**

A useful booklet dealing with various engineering courses available in London and the home counties is published by the London and Home Counties Regional Advisory Council for Technological Education. It is entitled *Engineering Education in the Region* and may be obtained, price 3s. 6d., including postage, from the Council at Tavistock House South, Tavistock Square, London, W.C.1.

# Reviews of Books

## THE IMPORTANCE OF BEING HUMAN

**By E. L. Mascall**

*London: Oxford University Press. Pp. vi + 118. Price 10s. 6d.*

It was explicitly laid down in the deed governing the delivery of the Bampton lectures in the University of Oxford that the same person should never give the course more than once. Subsequent history has in fact decreed otherwise, since a kinswoman of the founder has made it possible for "Bamptons" to be held in the New World, namely in the University of Columbia. The author of this book thus has the distinction of being the first "pluralist" in such a context. And this is fortunate in more senses than one, for it has enabled him to transpose into a rather different key the outlook behind his original discourses entitled *Christian Theology and Natural Science* (Longmans Green, 1956).

The present volume—the Columbia "Bamptons"—contains six chapters dealing with the uniqueness of man, body and soul, individual and society, nature and super-nature, man fallen, man in Christ. There are also some valuable notes and a bibliography. The writer is a leading Thomist of the Anglican Communion, but his sympathies are wide, and his erudition a rare combination of the mathematician's and the theologian's.

His thesis is exactly what the title proclaims, no more and no less. Frustration and distress arise when men try to be what they are not, especially if they are too easily pleased: more particularly if they aim too low, and act with enfeebled generosity, and even without romance. To be human is essential. All this is very timely when the responsibilities of scientists are so much in people's thoughts.

The fall of man is seen as a microscopic crack in a china vase, spreading far and wide its influence of disintegration throughout the race. Physicists will recollect how dramatically this metaphor is confirmed in nature: the strength of a rocksalt crystal made completely free from cracks (on an ionic space-lattice scale) approximates very closely to the theoretical figure, which is some ten thousands of times greater than that commonly observed. But what an amount of labour was involved in "achieving" such a "perfect" crystal! Man was indeed made lower than the angels "for a little while." If he wills it enough, he can still be "crowned with glory and honour."

F. I. G. Rawlins.

## FEEDBACK CONTROL SYSTEMS

**By Gille, Pelegrin, and DeCaulne**

*London: McGraw-Hill Publishing Co. Ltd. Pp. xx + 793. Price 128s.*

New books on the theory and practice of automatic control systems are now published so frequently that it is difficult to be enthusiastic about any of them, and particularly so when they are as expensive as this one. But it is gratifying to be able to say that this is not just "another book on servo-systems": it has several features which are both novel and useful and which distinguish it from most of the existing books. Perhaps the most important of these is that both the approach adopted and the general style of the book are different from that of most British or American books on this subject. In American textbooks the latest analytical techniques are described and used in a convincing and realistic manner, but they often lack an adequate account of the physical meaning of the equations, functions and processes described. On the other hand, whilst British textbooks lay great emphasis on the physical meaning of the quantities involved, it is rare to find in them an account of the more sophisticated methods of analysis that conveys any impression of practical utility. The authors of this book seem to have succeeded in combining the European and American approaches in a most happy manner, and have produced a textbook which, whilst making few concessions to the reader, is, nevertheless, easily readable. In addition, the reader is taken very quickly from first principles to a level at which his knowledge becomes of practical utility.

Parts I and II deal, respectively with the dynamics of linear systems and with linear servo-systems, including sampled-data systems. Both the harmonic approach and the pole-zero-configuration approach are described, and these two methods are then used side-by-side and are compared critically. Part III deals with non-linear servo-systems and includes an account of a recently developed technique for dealing with oscillations of on-off control systems. Part IV deals with servo-system

components and in Part V two examples of basic servo-system design are worked through in some detail. All these sections contain, in addition to a very comprehensive treatment of the usual topics, much additional new material from Russian sources. There are many diagrams, very clearly drawn and described, and enlarged copies of the more important charts are enclosed.

The book contains an interesting selection of examples to be worked by the student as well as a very much greater number than usual of examples in the text. There is also a 5-language (English, French, German, Russian and Spanish) glossary of automatic control terms, and a critical, but somewhat restricted, bibliography. It is a pity that there are so few references in the text, but this is a minor fault in an otherwise interesting and useful book. The price is high, but not unreasonably so in view of the scope and nature of the book.

A. E. De Barr.

## AN INTRODUCTION TO THERMONUCLEAR RESEARCH

**By Albert Simon**

*London : Pergamon Press. Pp. ix + 182. Price 35s.*

The field of research into the possibility of producing controlled power from the nuclear reactions of light elements is comparatively new. While serious research began about 1950, security restrictions prevented the spread of knowledge until 1958, when the field was thrown open at the second Geneva Conference on Atomic Energy. Since then, it has been apparent that there is a clear need for an account in which the many lines of thought, and the grammar and terminology of the subject are brought together ; so that both the non-specialist and the student can get to grips with this much publicized subject.

Dr. Simon's book is an important contribution towards satisfying this need. It is clearly written, it eschews complex mathematics, the physical ideas involved are presented in their simplest form, and they are related to actual devices proposed for producing controlled thermonuclear power.

However, as Dr. Simon explains, the book is based on lectures given in 1955, and no attempt has been made to include material presented after 1956. Moreover, it covers only American research. Thus it has a rather old-fashioned and provincial appearance after the revelations of the Geneva Conference. This is chiefly reflected in the form of presentation, and to a lesser extent in the omission of various topics—the most notable being plasma oscillations. One unfortunate feature is that the references are not up-to-date, and of the 49 given, only seven refer to articles in normal journals ; the vast majority are references to laboratory reports, even in cases where they have been republished in ordinary journals. Consequently, to search out references for further reading, the reader will have to go to other sources, notably the papers of the 1958 Geneva Conference.

The first three chapters deal with power balance considerations, and the arguments leading to the required conditions in a fusion reactor, notably that the core of such a reactor is at present envisaged as a hot deuterium plasma isolated from material walls by magnetic fields. The next four chapters deal with the various configurations of these fields which have been investigated experimentally and theoretically in particular with the Stellarator, the Pinch and the Magnetic Mirror configurations. Each is discussed from a rather particular point of view : thus the Stellarator section is much occupied with particle drifts in inhomogeneous magnetic fields, and with heating problems ; there is hardly any mention of instabilities ; whereas instabilities occupy a substantial part of the section on the Pinch. In each case Dr. Simon goes at some length into the potentialities of the proposal as a working reactor. There is a chapter on stability, dealing with the main points brought out by hydromagnetic theory. The last chapter, which is probably the most interesting for the specialist, deals with diffusion of plasma across magnetic fields. Here the reader will find the sole example in the book of a comparison between experiment and theory.

Thus, apart from this last chapter, the book is essentially an account of the principal proposals for making thermonuclear reactors. Dr. Simon works in a commendable amount of clear physics in the course of this account. But the physics of thermonuclear research is mainly the physics of fully ionized plasmas in magnetic fields. For a thorough and systematic account of this latter subject, the reader must go elsewhere.

R. S. Pease.

## TRANSISTOR CIRCUITS

**By K. W. Cattermole**

*London: Heywood & Co. Ltd. Pp. xii + 442. Price 70s.*

The author states that according to estimations some ten to twelve million transistors were in use in 1956 but that in fact this number of thermionic tubes was made each week. It would be interesting to know the present situation, but clearly thermionic valves are still with us and show no signs of being displaced completely, even perhaps in some fields where transistors have much to commend them. The small size and independence of battery filament space are obvious and powerful advantages of transistors but they have other special characteristics; for instance the author stresses in his introduction that they provide by far the best electronic approach to the perfect switch, and the present work makes this clear.

The book is written primarily for users of circuits. Thus the introductory chapters dealing only with the elementary theory of transistors are considered adequate for a general overall understanding of these devices. It is not a design book and in general provides an analytical treatment, using a minimum of advanced mathematics, of many circuits in which transistors can be used. Although the author makes an effort (chapter 16 for example) to stress the special applications where transistors have outstanding advantages, and although transistors and thermionic vacuum tubes are directly compared in some instances (for example briefly at the beginning of chapter 8 on high frequency amplifiers) one feels that, for the benefit of the many inexpert circuit users who naturally wish to apply transistors

whenever there are clear advantages in doing so, more attention could have been given to this point. Those already skilled in circuit techniques will have less difficulty, and there seems little doubt that for them this would be a scholarly and stimulating work, for it is clear that the author has done a great deal of original thinking.

Following the introduction and the chapter on elementary basic physics, there are chapters on electrical properties and elements of transistor circuits. Then follows perhaps the main part of the book, namely chapters on single stage, multi-stage, power and high frequency amplifiers. Further chapters deal with supplies and bias stabilization, negative resistance, binary circuits (naturally an interesting and very important chapter), waveform generation, counting and timing, modulation, detection and frequency changing, the measurement of transistor properties, and finally fields of application.

J. D. CRAGGS.

## EINFÜHRUNG IN DIE KERNPHYSIK

**By W. Riezler**

*Munich : R. Oldenbourg Verlag. Pp. viii + 382. Price DM 31.50.*

This is a most unusual introduction to nuclear physics. One's first reaction to the almost complete absence of any discussion of nuclear forces is that this is Hamlet without the Prince, but riper reflection shows that there is a good deal of method in this particular madness. The physics of the nucleus is by now a very well developed subject, but it must be admitted that it has been little influenced by what we know of the forces between individual nucleons. This book in the first half deals with the properties of nuclei, nuclear reactions and nuclear structure, and in the second half with more practical matters, such as particle accelerators, nuclear reactors, radiation detectors and practical uses of nuclear physics. Almost every page is illuminated by the great familiarity which the author clearly has with the practical side of his subject and in a quite remarkable way he manages to be both intelligible to the student and yet interesting and revealing to the expert.

This is the sixth edition of the book, the first having appeared in 1936, and it must be conceded that in some sections the subject matter has been brought up-to-date more thoroughly than in others. This partly results in somewhat old-fashioned methods, such as the use of natural radioactive sources being given more prominence than is usual in modern textbooks, and this is not a bad thing. But it also results in errors being perpetuated and this cannot be defended on any grounds. Perhaps the most glaring of these is the statement that the radius of the nucleus is given in terms of the mass number A by $R = r_0 A^{\frac{1}{3}}$, where $r_0 = 1{\cdot}42 \times 10^{-13}$ cm. This statement which in itself is wrong leads the author to speculate on the possibility of $r_0$ being exactly equal to the classical electron radius and thus "a constant of nature of far reaching importance." There is no method in this madness.

L. R. B. ELTON

## THE PHYSICS OF ELECTRICITY AND MAGNETISM

**By W. T. Scott**

*London : Chapman & Hall Ltd. Pp. xvi + 635. Price 70s.*

The serious teacher of electricity and magnetism concerns himself, sooner or later, with the logical development of his subject. When he reaches this stage he usually becomes dissatisfied with the development as he has known it previously. This is not altogether surprising as there are numerous alternative ways of presenting the subject and there is inevitably a rather vague relationship between the experimental basis and the abstract theoretical concepts of field, potential, flux, etc. The balance between theory and experiment is based on plausibility, intuition and logic. Without being unduly cynical it is probably true to say that acceptance of the theory at the early stage is founded more on familiarity than on logical deduction.

The book under review has arisen from the author's dissatisfaction with previous treatments of the subject. In his own development he has set numerous objectives, some of the more important of which are :

(*a*) the book should present a good balance between theory and experiment, training the reader's intuition by use of careful physical and mathematical reasoning ;

(*b*) it should be logically accurate, with a rock-bottom minimum of " it can be shown " statements ;

(*c*) the mathematical level of the proofs should be as elementary as possible, consistent with the requirements of logic ;

(*d*) It should make full use of earlier training in atomic physics.

It can be said that the author has gone a long way towards achieving these objectives. At all stages he strives after plausibility, acceptability, consistency and logical appeal. He discusses the significance and justifies the introduction of V, E, H, D, B, etc., etc. The scope of the book is quite conventional. The use of mathematical techniques, such as vector analysis and partial differential equations is done in such a way that there is enlightenment of the mathematical processes as well as the physical principles.

In his endeavour to satisfy his objectives the author is occasionally repetitive and slightly laboured. However, all in all, he has been highly successful in producing a satisfying and stimulating book well suited to the later stages of an honours course in physics.

M. R. GAVIN.

## EXPERIMENTS WITH THE MICROSCOPE

**By Nelson F. Beeler and Franklyn M. Branley**

*London : Faber & Faber Ltd. Pp. 134. Price 16s.*

This book is obviously intended for a wide audience. The publishers' maintain that " Apart from the microscope, the necessary equipment is found in any home." The range of experiments suggested by the authors seems to demand a microscope which might cost nearer forty pounds than twenty. Perhaps the usefulness of the book should be assessed in terms of more specialized audiences.

A great deal of ground is covered. The parts of a microscope are described and identified on a fairly adequate diagram. Techniques of focussing, illuminating and mounting slides and simple methods of cutting sections are explained. There are also brief accounts of more refined techniques like photomicrography and the possibilities of the electron microscope. Practical advice, however, turns on the kind of things which might be observed by an amateur with microscopes magnifying by up to 400 diameters. More care might have been taken to relate the stated results of observing specimens of protozoa, textiles, moulds, yeasts, blood and bacteria and so on, to the kinds of magnifying power necessary to achieve these results.

In addition there is a certain amount of theory and side references are made to the history of microscopy and to the topical uses of microscopes in, for example, crime detection.

The text is clear and generally speaking seems directed towards adolescents although the authors do not seem to have decided whether or not their readers are likely to be sophisticated. Since a lot of ground is covered every topic is treated very cursorily. Few teachers of physics, for example, would be happy to use the chapter on " How a microscope works." Indeed useful though the practical tips might be, practical work and theoretical explanation are not differentiated in the text sufficiently to make this a useful textbook. Enthusiastic youngsters might take the trouble to distinguish experiment from explanations of phenomena observed. Non-specialist teachers called upon under present conditions " to teach a little science " would find the book useful so might many teachers of general science.

There are some irritating editorial slips. For instance there is no picture to which the phrase " the picture shown here " (p. 119) might easily be related. "Plate 3" (p. 128) should read "Plate 9". The many diagrams and photographs, in contrast to the text, are not very adequate if one of their main functions is to stimulate interest.

Altogether a difficult book to evaluate. It has no obvious competitor, and it meets in lively manner a need felt by many teachers. But at 16s. it is rather highly priced if it is to appeal to the lay reader. It would be a good book to have in a school library for the use of science club members.

B. Holmes.

## HYPERSONIC FLOW THEORY

**By W. D. Hayes and R. F. Probstein**

*New York and London: Academic Press Inc. Pp. xiv + 464. Price 92s.*

The book is directed to students and research workers in the field of modern gas-dynamics and to hypersonic aerodynamicists. The authors divide the hypersonic features of a high speed flow into those of a " hydrodynamic " nature which arise because the Mach number of the flow is large and those of a physical or chemical nature which arise because the energy flow is large. The book by design concentrates on the former largely to the exclusion of the latter. It does, however, include consideration of those rarefied gas flows which can be treated either as continuum or as free molecule flows whilst eschewing superaerodynamic developments which by definition involve treatments of the Boltzmann equation.

The authors themselves say " The book serves as a vehicle for original work of the authors. Most of this original work was done in the course of preparation to fill in the gaps . . . " In short this is a specialist's book—the authors regard courses in gas-dynamics and compressible flow as prerequisites—but it is a book which specialists must have. It can be thoroughly recommended on this basis with perhaps the one reservation that in places it makes the material appear harder than it need; it is thoughtful and thought-provoking.

L. Howarth.

## CLOSE BINARY SYSTEMS

**By Zdeněk Kopal**

*London : Chapman and Hall Ltd. Pp. xiv + 558. Price 105s.*

At first sight this work, on the relationship between pairs of stars evolving in such close association as to be almost in contact, might appear so specialized as not to attract many general physicists. Two facts make us commend the book to the world of physicists against any such hasty shyness. Firstly, it is a classic of the best kind of astrophysics to-day practised : a cautious but tireless exploration of every avenue between fact and theory, carried out with a rigour of criticism which is sometimes lacking in to-day's presentation of the physical problems of astronomy. Secondly, even the most earth-bound laboratory worker will be stirred to delight at the unfolding of arguments by which an optically single point of light can reveal the interactions of the hidden binary pair ; analysis of the photometry of their mutual eclipsing, and the periodic Doppler displacements of the spectra as the pair move in orbit around the common mass-centre, yield through shape, width, asymmetry of curves and line-contours, the masses and sizes, the spin, the atmospheric structures, and even the equipotential surfaces whose intersection allows streams of hot gas to emerge from one of the pair and circulate as fantastic halo around the two. The evolutionary significance of these interactions has led in the past to many theories ; Kopal is a corrective to the more hasty of these, and lays the mathematical foundations for many years of future work all over the world, and for the programs of many of the greatest observatories. Indeed the book will be a research-director for a long time in the astrophysical centres of Europe and America ; and it sets a standard to physicists in many fields of research—especially to some who tend to imagine that astrophysics is not an exact science.

Martin Johnson.

## APPROXIMATIONS EXPÉRIMENTALES ET NUMÉRIQUES

**By A. Lefrancois**

*Paris : Revue d'optique. Pp. 128. Price 660 French francs.*

This little book discusses in great detail and in an elementary manner the errors in measured quantities

and the degree of accuracy of calculated quantities derived from them. The first chapter deals with systematic and accidental errors, refers to the error curve of Gauss, and comments usefully on the precision of measuring instruments.

The second chapter shows how the relative error of any quantity or combination of quantities can be calculated, using simple algebra or differentiation. Finally, all this is applied to a number of examples in physics, many of which are of sixth-form level. As is fairly usual in continental books there are, however, no collections of exercises for the student.

The author is on the staff of the School of Applied Optics in Paris, so it is not surprising that many of the examples are taken from optics. He has written an attractive and lucid monograph, obviously based on " une solide expérience pédagogique."

In welcoming the evidence that in one school in Paris so much importance is attached to the estimation of errors, one would like to think that it is equally true of schools and colleges in this country.

J. Topping.

## ASTRONOMY

**By Theodore G. Mehlin**

*London : Chapman & Hall Ltd.; New York : John Wiley & Sons, Inc. Pp. viii + 392. Price 64s.*

This is a very American book : it is written with the mixture of engaging innocence expected to appeal to a somewhat childlike public, together with ready handling of highly technical argument, the speculative character of which is not always obvious.

The price is high, and Gamow is mentioned and Eddington not. The photographic illustrations are lavish—mostly from U.S.A., and the diagrams are often ingenious, and under an apparent crudity very informative. For example, those concerned with sidereal and synodic month, the harvest moon, and tidal phenomena. The historical references are valuably educative, and the balance of topics good. For instance the usual emphasis on nearby objects is abandoned, and stellar structure treated first : indeed the moon comes later—among the sputniks. The geophysical sections are especially good, Coriolis forces being introduced more clearly than in any popular book remembered. It is good to see the cosmological section stressing the work of Weizsäcker who is too often ignored in any but a serious treatise.

Martin Johnson.

## BEITRÄGE SUR PHYSIK UND CHEMIE DES 20 JAHRHUNDERTS

**By O. R. Frisch, F. A. Paneth, F. Laves and P. Rosbaud**

*Braunschweig : Friedr. Vieweg & Sohn. Pp. 285. Price DM 29.50*

Between November, 1958, and October, 1959, three of the foremost German physicists—Lise Meitner, Otto Hahn and Max von Laue—attained the age of eighty; this book forms a tribute paid to them by thirty eminent physicists from all parts of the world. It takes the form of a heterogeneous collection of essays varying in length from one page to thirty, in vein from the light and inconsequential to the weighty and deliberate, in content from the historical to the purely scientific. About two-thirds of the writing is in German, one-third in English and the rest in French, although several of the contributors have quoted freely from languages other than their main one.

It will be seen that the book is not one that is to be read from cover to cover; it is rather to be dipped into according to the mood of the reader. If he wishes to pass an odd moment, he can gain a vivid glimpse of the way Ewald was influenced by Laue; if he wishes to see an important chapter in physics unfolding itself, he can follow Heitler through the history of $\beta$ decay (warts and all !); for precise information about a new development in X-ray diffraction—the use of anomalous scattering—he can refer to Bijvoet's article. There is something for almost everyone—even, at the end, a phantasy by Rosenblum for those who sometimes like to dream.

What is the value of such a book ? I am sure that there are those—the neat and tidy-minded—who would say that it has no value at all. It cannot be classified. It contains papers on quite different subjects. It treats some episodes with frank irreverence. (" The verdict of not a few theoretical physicists (about some ideas of Dirac's) left nothing to be desired in clarity : madness.") To my mind its chief value is as an antidote to textbooks.

The textbook must of necessity try to present a subject in a systematic way; its contents must be carefully parcelled and labelled. Yet we know that science is not carried on like that: scientists make mistakes, they miss the obvious, they make their deductions in the wrong order; then perhaps everything is put right, either with a flash of individual insight or with the laborious co-operation of a team of people. There is no royal road to scientific success. From this book we see all sides of scientific endeavour, and for this reason I hope that it will be widely read.

But at what stage should it be introduced to students? It will not help them to pass examinations !

H. Lipson.

## CONTEMPORARY PHYSICS — A JOURNAL OF INTERPRETATION AND REVIEW

**Edited by G. R. Noakes**

*London : Taylor and Francis Ltd. Pp. 80. Price per part 5s. Subscription price per volume of 6 parts 27s.*

The subtitle of this new journal is " A Journal of Interpretation and Review " and if one is to judge a journal by its very first number, then it must be said that it comes down fairly heavily on the side of " Review." There are authoritative articles in a variety of branches of physics, all excellently written and all very clear for those with the necessary background. This latter unfortunately varies from a bare pass at A-level to a very good honours degree very recently acquired. This variation is much too large and is connected with the present lack of balance of this journal. Thus any physicist would I think be fascinated by the account of " Light Sources using Radioisotopes," which actually is

neither interpretation nor review, but a splendid piece of applied physics not apparently previously published. On the other hand the articles on " molecular beams " and on " the structure of the atomic nucleus " are strictly review articles and would not be out of place in one of the many well-established review journals. They must make very difficult reading for " teachers in schools and in technical colleges, scientists in industry, and others striving to keep in touch with modern developments," unless they are already in touch with these modern developments. There is really nothing at all that could be strictly called " Interpretation," although a most interesting article on von Humboldt comes close to it. One small point in connection with this article—before Abraham Mendelssohn became the father of his famous son, Felix, he was the son of his famous father, the philosopher Moses. This is perhaps more relevant in connection with his scientific interests. The deficiency in interpretative articles may well be remedied in future issues.

Altogether, the journal looks far too learned and a glance across the Atlantic might have shown how to liven it up without cheapening it. The lay-out, the numbered equations, the graphs make no allowance for the man who wishes to improve his mind in an armchair by his fireside late in the evening. (He might for instance like to know something about the authors of the articles beyond their addresses !) And for the sake of financial solvency it is hoped that the advertising policy will get a great deal more imaginative. Surely this is the place to advertise industrial careers for physicists and the latest commercial electron microscope, as well as new books, film strips, instructional films and many other things. Instead, we are invited on eight pages to buy the other learned journals of the same publisher.

It seems a pity that so much criticism is called for, particularly as there is a danger that the infant may die before he has had a proper chance to come to life. There is great need in this country for a journal which will do what this one sets out to do and we must give it every chance to prove itself. Let us all then take out a year's subscription and judge the journal again at the end of that time.

L. R. B. Elton.

# Obituary

## C. T. R. WILSON (*Honorary Fellow*), died November 15, 1959

Even among first-rate physicists C.T.R. was someone special, even unique. From the study of an apparently unimportant, if intriguing, oddity, he developed a technique, or more accurately a series of techniques, which have been and still are essential to the development of some of the most important branches of physics.

C.T.R.'s observations of clouds on Ben Nevis in 1894 are worthy to be ranked with those of Galvani in the butcher's shop. Not that clouds were new, or even the idea of nuclei, but his study of them in connection with the effect of the new X-rays led first to the earliest measure of $e$ for gaseous ions and then to the earliest experiment by which particles of atomic dimensions became visible as individuals. It is not too much to say that besides its enormous value as a research tool the cloud chamber has altered the whole attitude of physicists to atomic particles. " Reality " is a word which is best avoided in physics—perhaps in philosophy also—and we have no good equivalent for " anschaulich," but Wilson made physicists feel that atoms are knowable, almost lovable.

Compared with the very greatest names his field was limited, but it was peculiarly his own. He and no other made the cloud-chamber a great experimental tool, though others have developed it still further. He did pioneer work on thunder clouds and made important measurements of their electric fields. Though his theory of how the charges inside them are produced is no longer accepted, it is significant of the difficulty of the problem that of various theories which have been suggested to replace it none can be said yet to be securely established.

Wilson was an excellent teacher of individuals, as the present writer knows from personal experience. He was reputed a bad lecturer, and sometimes certainly was, though even here it was the manner and delivery that was at fault rather than the substance.

As a man, his modesty and sweetness of disposition made him singularly attractive. Few men have been so generally loved. He retained his interest in physics till the end, and in his late 80's was willing to make the double journey from Scotland to Harwell in a day for the inauguration of a new reactor.

He seemed always to go straight to the point, evading detail and grasping essentials. In his genius for simplicity his work fitted his character.

G. P. Thomson,
*President.*

# Letters to the Editor

**A parent's view of education**

I am sure that I have already occupied far too much space in the *Bulletin*, and it is therefore with much trepidation that I dare to ask for still more—and that for the purpose of entering the lists against no less a personage than you yourself.

I refer to your article on "A Parent's View of Education." Most of this I entirely agree with ; what I disagree with is your rather disparaging references to elementary practical physics. I am concerned because I know that your views are shared by many other people, and, if they become more widespread, I believe that physics as a whole will ultimately suffer.

I can best make my point by comparing physics to a magnificent building. Like any enthusiastic builder, the physicist is most proud of the impression it gives to the beholder ; he delights in Maxwell's equations, in wave mechanics, in the equivalence of mass and energy ; while taking his conducted parties round, he is naturally anxious that features such as these should be properly appreciated and their place in the complete design fully understood. But he also knows that there are such things as foundations and drains, electricity, gas and water supplies, heating and ventilation. Without these, the building would be a sham, comparable only with a set built for a motion picture, and of no permanent value. Those who wish to appreciate the building in its entirety will want to have these explained as well ; they are as much a part of it as are the flying buttresses and the soaring pinnacles.

These foundations and supplies correspond, I maintain, to elementary physics—particularly practical physics. It *can* be treated with imagination, and this would be my plea to the teachers of our children. Explain that the very existence of a reflexion in a mirror is a challenge to the imagination, and that simple things like pins can provide a means for investigating it ; that only a hundred years ago the problem of the nature of heat was exciting the foremost physicists of the world, and that they did not disdain pieces of brass and calorimeters: that we are still not sure of the basic facts of simple things like magnets and the Earth's magnetic field. Then these subjects will no longer appear as an unnecessary drudgery, and I firmly believe that the later advanced work will be more properly appreciated and understood.

After all, Sir, let us keep a sense of proportion about what we are doing. The ideas of what constitute "flights of the human mind" and "creative imagination" must be very different in the mind of a child and that of a mature physicist. I can well remember the excitement I felt when I first realized that the image of a pin had a precise position in space and that I could locate it with only primitive equipment. I should be sorry if future generations of physicists were to be denied this same experience !

H. Lipson (*Fellow*).
Manchester College of Science and Technology.

Mr. Clarke replies :—

Argument by analogy is always dangerous and often—as in Professor Lipson's letter—positively misleading. Incidentally, Professor Lipson might have chosen a happier analogy for elementary practical physics than drains.

In my article I tried to emphasize that the great majority of children leave school with no idea of what physics is really about, and that elementary physics *as taught* in most grammar schools fails to arouse any lasting interest in the subject. Teachers may believe that they are laying the foundations of physics but, even ignoring the crucial question of what the foundations of physics really are, is this process as important in school education up to the age of sixteen as it would seem to be at first sight ? Professor Lipson believes, or implies, that something like the course for G.C.E. physics *as at present taught* is a necessary preliminary for those who will never specialize in science but to whom we wish to give a broad outline of physics as part of their cultural background. I deny Professor Lipson's case completely ; I doubt if he could sustain it even for the future specialist. Both Professor Lipson and I know personally some distinguished professional physicists who lack these apparent foundations since they never studied physics at school. History certainly proves that one may become a Fellow of the Royal Society and even win the Nobel Prize for physics and yet never have known the challenge to the imagination posed by reflections in a mirror on a school laboratory bench.

Let me emphasize that I was not attacking practical work, in which I believe. What I questioned was the value of some of the conventional experiments. Some teachers may find these simple experiments valuable and I do not intend to be forced by Professor Lipson into the false position of appearing to want to exclude simple experimental work, which I merely happened to quote to illustrate a bigger issue. What I deny is the *essential* nature of much of this work. Any experimental work must be judged primarily by the use the teacher makes of it. If a teacher *chooses* exercises because he personally finds that they are valuable I certainly do not wish to deny him that freedom ; what is more commonly the case, I believe, is that we impose upon the teacher a scheme of experimental work that is dictated largely by convention and ease of examination. Good teachers may succeed, as Professor Lipson suggests, in challenging imagination by the use of pins and mirrors but I wish we could see more evidence of this in the children who leave school immediately after passing the G.C.E. examination in elementary physics. In the *Bulletin* of last July I published the talk which Miss Raven gave at the Education Group conference. Speaking of grammar school entrants, she says, "They are prepared, even anxious, to find science exciting . . . it is all great fun, . . . from this promising beginning why do we largely lose the sense of discovering things before they are three years older ?" This remarkably honest query is probably a more valid and more widely applicable

comment on elementary physics teaching than is Professor Lipson's touching faith in pins.

Let me return to the point that I tried to make in my article. Physics ought to be part of the cultural background of everybody ; even if the physics courses in grammar schools were perfect we should need to do some fundamental thinking about courses for the much larger number of children who do not go to grammar schools. My belief is that it is possible and desirable to devise a course that will give a broad view of what physics is about, without going through all the drudgery of present grammar school courses ; this would involve a new assessment of what is basic to a *non-specialist* understanding of physics. This is where Professor Lipson appears to differ from me fundamentally. He implies that the necessary foundations for the specialist and non-specialist are the same. They are not. If physics were taught only to future specialists, his case might be better, his analogy would at least be plausible and his last sentence would have some relevance. But physics is not, or ought not to be, taught only to specialists and, this being so, his case is patently false.

I should like to follow him in his analogy. Drains and foundations are undoubtedly matters of crucial importance, although (to make his analogy more strictly relevant) I doubt whether students of architecture spend several years exclusively studying drains and foundations before being allowed to show interest in the more exciting aspects of their profession. But how much do these topics matter for the non-specialist ? For example, could Professor Lipson give an opinion on the relative architectural merits of, say, Lincoln Cathedral and the Beckton gas-works only after inspecting the drains ? Would Rome mean nothing to him until he had visited the sewers ? I do not suggest that we should be indifferent to sewers or damp-courses ; the whole argument is about their proper place in the education of those who will not spend their lives in the specialist study of them.

Again, if I may change the analogy, I doubt whether Professor Lipson would argue that children should be taught nothing about the use of the English language unless the course first covered—with necessary exercises —the obvious foundations of Anglo-Saxon, Old English, and Middle English with a proper emphasis upon palaeography which, for all I know, may be presented by good teachers as an exciting challenge to the imagination. These are foundations needed by graduates in English, but if Professor Lipton retorts that the appropriate foundations in school are spelling and syntax, I agree ; what is a foundation for a specialist may be quite unnecessary for anyone else. In other words, " foundations " must be thought of in terms of the structure one proposes to erect upon them. Some of us, whose education is clearly lacking in specialist foundations, have yet managed to find in English literature an abiding joy that perhaps we have no right to experience; for a subject such as physics we may have to aim much lower, but is it impossible to give to at least a substantial proportion of children such an insight into physics that the subject will become a similar source of pleasure and stimulation ? And do pins and mirrors really represent our last word on the way in which this might be done ?

**The Graduateship Examination General Paper**

I am disturbed about the General Paper published and commented upon in the September *Bulletin* (Vol. 10, No. 9). It appears that for some candidates (*loc cit*, p. 228) a pass is a necessary qualification for Graduateship of the Institute. Of what use in their jobs will be the knowledge they are expected, by this paper, to possess ? Some candidates will have left school early and come up the hard way, not being born with the educational silver spoon in their mouths, but doing most of their studies in their spare time. Such candidates will surely be specializing in physics already, to some extent, in their daily work. Is there a shortage of physicists, and do we wish to attract or repel these candidates ?

As to the content of the paper—knowing where to find information is more important than knowing it in some circumstances, and there are numbers of evening class courses where such candidates could learn such subject-matter subsequently, *if required*. As to the fairness of the paper—it can rarely be more than a retrospective probing of the candidate's ignorance (bearing in mind the limited field I have referred to above)—an inevitable ignorance, in the circumstances. Its content can vary widely from year to year, thus rendering reasonable preparation impossible (and five out of seven questions must be answered, remember). As to performance, it is obvious that the N.L.C.S. girls would do better at it, and the comparison borders on the odious. What purpose does this paper serve ? Is it a professional qualification or a general educational one that we offer ? Assuming a prospective Honours undergraduate needs "A" level passes in science subjects and/or mathematics, need he also have *any* of the knowledge here demanded ?

A second aspect (the Examiner's comments ; *loc cit*, p. 225) is more disturbing. Do we pause to consider what these prospective members may think of *us* ? Whether they believe us to be snobbish and exclusive or not, will they not judge us to be gravely discourteous in quoting, *verbatim*, parts of answers in a document available in the libraries of schools and colleges (the comparison with N.L.C.S. being particularly pertinent here) ? Is this an indignity to which those of us who have not taken the Institute's examinations have ever been subjected ? If I remember rightly, the authorities in charge of University and other public examinations are most circumspect in these matters. Published papers—yes, to warn the prospective examinee what he is in for. But as to the intimate details of candidates' performances there is silence, at least in public.

Obviously a Graduate of the Institute will wish to feel free to offer himself for any kind of post in physics, including teaching and lecturing, and equally obviously we must ask ourselves what minimum standards are required to maintain the reputation of the Institute. But is this General Paper the best and kindest way of tackling the problem in the limited field of candidates above-mentioned ?

Is the real trouble an undue leniency in English requirements at H.N.C. level (as Mr. Clarke suggests) or even earlier ?

Two candidates " passed the necessary papers in physics but failed the General Paper, which they will be required to repeat " (*loc cit*, p. 228). Can we begin to

imagine their keen disappointment at having been encouraged thus far and then " ploughed " in this of all papers ?

I would be most grateful for enlightenment.

A. H. Lee (*Associate*).

6 Barn Crescent,
Stanmore, Middlesex.

Mr. Clarke replies:—

The basic general educational requirement for membership of the Institute is either matriculation of a British university or the General Certificate of Education with not less than five passes at the Ordinary level, of which one must be English Language, and at least one other must be from English Literature, History, Geography, a classical or a modern language. In essence these requirements have been unchanged almost since the Institute's foundation and the by-law requiring evidence of general education has been approved by members. I certainly did not lay it down. It is against this background that one must look at the General paper of the Graduateship examination, because the paper represents one of several concessions which the Board has made to candidates who have studied part-time for National Certificates in Applied Physics ; some may feel that these concessions have been too generous. The General paper is intended to give an opportunity to these students to provide some evidence of general education without having to sit for the General Certificate of Education. Dr. Lee may believe that we ought not to require evidence of general education from anybody, although I hope that few members would agree with him; what he does not appear to recognize is that the regulations exist and that the General paper is not an imposition but a concession.

I am, of course, quite prepared to admit that the General paper, like any other, could be improved. What I do not accept is that it demands more factual knowledge that it is reasonable to expect from a man in his twenties. How low an estimate of these candidates does Dr. Lee adopt ? I try to devise a paper that merely provides an opportunity for candidates to show whether or not they can write tolerable English ; the questions do not involve more factual knowledge that I should expect most children of 16 to possess—and to retain when they leave school !

These candidates are not people we have selected at random from passers-by. We have not asked them to take the examination. They have chosen to take it and, presumably, they think that they have some hope of passing. They have seen, or can have seen, the papers previously set and they know the general nature of the paper. The performance of some of them indicates merely that their claim to an acceptable degree of literacy is sheer effrontery and for such candidates I see not the slightest objection to the quotation, anonymously, of some of the more outlandish efforts. Nor do I share Dr. Lee's easy acceptance of the situation. To me these candidates suggest that there is something seriously wrong with our educational system and I see no virtue in pretending that this is not so.

Dr. Lee suggests that the candidates should know where to obtain the information required in this paper but that they need not be able to quote it without preparation. With the general principle I have much sympathy but in this particular context I have none at all. The thought of students having to attend evening classes where the subject matter could be learnt if required is surely rather comic when one considers the nature of the knowledge demanded. Are we really to assume that a 25-year-old Englishman needs to attend an evening class to discover the contents of *Punch* or to learn the names of three Presidents of the United States of America ? Dr. Lee should remind himself that no one is expected to submit a perfect script ; any candidate who knew the few facts required for three questions—and could set them down in reasonable English—would pass.

I am a little tired of the use of the alleged shortage of physicists to justify every proposed relaxation or modification of educational standards. The candidates that I rejected may, for all I know, be budding Faradays but, if this is so, their failure in the Graduateship examination will in no way limit the scope of their scientific work. The only result is they cannot become Graduates of the Institute because they have not provided adequate evidence that they satisfy the Institute's requirements of general education. When a sufficient number of Fellows and Associates of the Institute feel that it is wrong to demand some evidence of literacy from those seeking membership no doubt the regulation which has existed for 40 years will be rescinded ; until it is it seems to me to be better to make an honest attempt to assess compliance with it than to pretend that the rule does not exist. There are enough people who accept the heresy that scientific competence often goes hand-in-hand with illiteracy, and it is a pity that members of the Institute should appear to support such a view.

Dr. Lee uses the word snobbery, a loaded, emotional word which I dislike and which has little meaning. However, if it is snobbery to prefer members of a professional body to be able to speak and write their own language with tolerable accuracy and to be aware of some of the more rudimentary facts about the society in which they live, I am a quite impenitent snob.

# The Institute's Journals

PRINCIPAL CONTENTS OF THE DECEMBER, 1959, ISSUES

## *Journal of Scientific Instruments :* Volume 36, No. 12

**Nuclear resonance absorption circuit. Part 1. Sensitivity considerations; Part 2. Practical design.** By F. N. H. Robinson.

The new circuit described in Part 1 has the sensitivity and flexibility of conventional circuits using a separate oscillator, combined with the convenience and freedom from microphonics of marginal oscillator circuits. In particular, it permits the use of very low levels of oscillation.

Because the factors governing the sensitivity of conventional circuits are not widely known, this first paper is largely devoted to their delineation. Only the principles and theory of the new circuit are given in Part 1. Practical design details are relegated to the second paper.

**Compact calorimeter for measuring the overall thermal efficiency of freestanding fires and stoves for room warming.** By M. W. Thring, F.Inst.P.

The heat output by convection and radiation of a modern solid fuel room heater is best measured by a calorimeter absorbing all the heat. By using a comparatively small water cooled box enclosing the heater good absolute accuracy and rapid response can be obtained and the heat output should not differ by more than 1% from that in an average large room. Such a box can be simply constructed from insulated "tube-in-strip" and the air flow in and the rate of loss of weight of fuel in the heater can be continuously measured.

**Multi-channel photoelectric scanning instrument for sizing microscopic particles.** By B. B. Morgan and E. W. Meyer.

Development of a photoelectric scanning instrument for counting and sizing particles dispersed on a microscope slide has continued and the performance of a five-channel version has been assessed. The size distributions of a number of fractions of coal particles of sizes down to 1·5μ determined by the instrument agree (to within 15%) with those from visual counts. Comparative sizings are given also of alumina particles (5 to 20μ) and of transparent profiles in an opaque film (5 to 20μ). Comparative counts are given of the number of particles 1 to 5μ in thermal precipitator samples of coal. Data are presented on the reproducibility of instrument sizings and an indication is given of the time needed for a determination.

**Method of measuring displacement using optical gratings.** By D. L. A. Barber and M. P. Atkinson.

The paper describes a method of using three diffraction or shadow gratings for accurate linear measurement. Comparison between the gratings produces two alternating signals, and the change of phase difference between the signals is proportional to the distance measured.

**Stabilized torque magnetometer.** By W. F. Archenhold, A. C. Brown and J. E. Thompson.

An improved torque magnetometer has been developed which enables measurements of torque to be made with high precision and under conditions of complete stability.
The specimen torque is balanced by means of an electric current passing through the coil of a moving coil meter movement, which replaces the normal torsion head and wire. A small permanent magnet is mounted on an extended movement pointer, so that one pole is capable of restricted motion in the field of two opposing current carrying coils, which provide the necessary stability.
The principle employed for producing stability is capable of application to fields other than magnetism.

## *British Journal of Applied Physics :* Volume 10, No. 12

**Effect of crystallographic twins on the d.c. and a.c. properties of nickel-iron alloys.** By J. E. Thompson.

A number of alloys of nickel-iron (equal parts) have been prepared from pure materials by powder metallurgy techniques. The degree of cold rolling and the annealing temperature have been varied in an attempt to obtain the optimum magnetic properties in the material after magnetic annealing. It has been found that crystallographic twins of varying number, length and thickness are produced during the annealing process. The effect of these twins on the coercive force and alternating total loss is discussed.

**Thermal transients in graphite-copper contacts.** By W. Davies.

Calculation of the transient temperature distribution in a current-carrying electric contact is important in those cases in which the contact members make actual contact for only a comparatively short time. Special reference is made here to the contact of graphite and copper, and consideration is given firstly to the case in which the metal is clean, and secondly to that in which the metal is covered with a film of oxide. Finally, the decay of the temperature at a contact spot following the separation of the contact members is discussed. The analysis treats of a single circular contact spot of very small radius.

**Glow discharge characteristics of helium-neon mixtures.** By G. F. Weston.

The maintaining and breakdown potentials for a number of helium-neon mixtures have been determined over a pressure × distance ($pd$) range of 1 to 75 cm mm of mercury. The normal cathode fall and the minimum breakdown potential were higher for mixtures containing from 1 to 5% neon, than for either of the pure gases. At higher $pd$ values the breakdown potential was lower for mixtures of the order of 50% helium–50% neon than for the pure gases. These results suggest reactions between the two gases affecting the ionization coefficients. Charge exchange processes, detected by Oskam in the afterglow of such mixtures, are consistent with the emission spectra of the glow discharges, and are the probable cause of the variations.

**Method for photographic identification of microscopic radioactive particles.** By J. Sisefsky.

A method is described for identification and microscopy of small radioactive particles mixed with a large amount of inactive ones. The particles are prepared on a celluloid coating on a glass plate. The plate is coated with nuclear emulsion in gel form which is reversal developed *in situ* leaving the active particles visible, in the centres of clear circular spots against a brown transparent background.

**Study of cadmium sulphide crystals grown from the vapour phase in a stream of argon.** By J. Woods, A.Inst.P.

Crystals of cadmium sulphide have been grown by reacting a stream of argon containing cadmium vapour with a stream of hydrogen sulphide. The variations in crystal habit which occur are very similar to those reported for ice crystals by Hallett and Mason. Growth features were studied using a metallurgical microscope. Although growth occurs in layers, spirals were only observed on rare occasions. The evidence indicates that ordinary two-dimensional nucleation over a plateau is more common, and is affected by the impurities added. Nucleation also occurs at sites on the edge of a crystal face or at the apexes of re-entrant angles between growth steps from neighbouring sources. Various types of cavity have also been observed in the volume of some crystals, and possible methods of formation are discussed.

**Torsion balance measurements with molecular beams.** By D. W. Bassett and A. J. B. Robertson.

A torsion balance is described for measuring the momentum carried by the molecules in a molecular beam with an intensity of about $10^{12}$ mol./s or more. The beam struck a vane suspended on a platinum fibre 3$\mu$ in diameter. The balance could be used at elevated temperatures. At room temperature, measurements of the balance deflexion were made to 1 part in 500, under favourable conditions. An investigation was made of the intensity of a molecular beam of carbon dioxide formed by a fairly simple molecular-beam generator, which is described. Deviations of gas flow from molecular flow and attenuation of the beam by scattering were important factors.

**Steady-state temperature distribution in solids undergoing certain change of property.** By T. J. Mirsepassi.

In the design of high-temperature equipment, two problems are often encountered: (1) determining the effect of slow changes of the thermal conductivity (which can occur as a result of chemical and/or mechanical factors) on the thermal behaviour of the equipment, and (2) finding the most efficient combination of materials for the design of the equipment when several materials are available. Both of these problems are customarily solved by trial-and-error techniques. In this paper, it is first shown that the temperatures before and after such changes of the thermal conductivity are related by simple linear equations. It is demonstrated that the process of trial-and-error in the solution of the above problems can be entirely eliminated by the use of these simple equations.

## UNIVERSITY OF OXFORD
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1. The Committee on Pressed Steel Fellowships proposes to make elections in Hilary Term 1960 to fellowships to commence at the beginning of the academic year 1960/61. The number of the elections made will depend on the strength of the field.
2. The fellowships (which are open equally to men and women) are for research in the physical sciences, these being deemed to include organic and inorganic chemistry, physical chemistry, chemical crystallography, physics, colloid science, engineering, metallurgy, or any other subject of study which in the opinion of the committee comes within the scope of the physical sciences.
3. In the selection of fellows the committee will have regard principally to capacity for original work ; and it will normally be a condition of eligibility that fellows shall by the effective date of their appointment have taken the degree of D.Phil. or its equivalent at another university.
4. The annual stipends of fellows will normally be within the range £700 – £1,000. The stipend of a particular fellow will depend on his age and qualifications.
5. Fellowships will normally be tenable for three years.
6. Applications should reach the Registrar, University Registry, Clarendon Building, Oxford, not later than February 13, 1960. Each candidate should submit with his application :
   1. Date of birth ;
   2. a statement of his career to date (including degrees obtained) ;
   3. the names of two referees (one of whom should be the head of the department in which he is at present working) ;
   4. copies of any published papers ;
   5. a statement of the department in which he wishes to work, giving an indication of the nature of the work which he would propose, if elected, to carry out.

### UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE

Applications are invited for the post of ASSISTANT LECTURER or LECTURER IN PHYSICS. Applications (six copies) should be sent not later than January 2, 1960, to the Registrar, University College, Cathays Park, Cardiff, from whom further particulars may be obtained.

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3. It will normally be a condition of eligibility that fellows shall at the effective date of their appointment have taken the degree of D.Phil. or its equivalent at another university.
4. The annual stipends of fellows will normally be within the range £700 – £1,000. The stipend of a particular fellow will depend on his age and qualifications.
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Middlesex County Council Education Committee, BRUNEL COLLEGE OF TECHNOLOGY, Woodlands Avenue, Acton, W.3. Department of Physics, Advanced Courses of Lectures, Spring Term, 1960. Theory and Use of Insulating Materials, January 19 to March 15. Weekly 7-8.30 p.m. Lecturers : Mrs. C. G. Garton and members of research staff of the Electrical Research Association. Basic High Vacuum Technology, January 11 to March 28. Weekly 7-8.30 p.m. Lecturer : Mr. D. J. Pacey (Senior Lecturer in Physics, Brunel College). Industrial Radiology, March 1 to April 5. Weekly 7-8.30 p.m. Lecturer: Mr. J. C. Rockley (A.I.D. laboratories). Applications of Semi-Conductors, January 14 to March 17. Weekly 7-8.30 p.m. Lecturers : Dr. C. A. Hogarth followed by specialists from Industry and Government Laboratories. Details of the above courses and forms of application for enrolment may be obtained from the College. A fee of £1 is charged for each course.

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